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Priority Papers

PATENT
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Applicants:	Kaj Borge HANSEN et al.	Conf:	1575
Application No.:	10/057,848	Group:	2862
Filed:	January 25, 2002	Examiner:	Unknown
For:	AN ELECTROACOUSTIC TRANSDUCER		

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PRIORITY LETTER

April 23, 2002

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Washington, DC 20231

Dear Sirs:

Pursuant to the provisions of 35 U.S.C. 119, enclosed is/are a certified copy of the following priority document(s).

Application No.	**Date Filed**	**Country**
PA 2001 00138	January 26, 2001	Denmark

In support of Applicant's priority claim, please enter this document into the file.

Respectfully submitted,

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Patent application No.: PA 2001 00138

Date of filing: 26 January 2001

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This is to certify the correctness of the following information:

The attached photocopy is a true copy of the following document:

- The specification, claims, abstract and drawings as filed with the application on the filing date indicated above.

Patent- og Varemærkestyrelsen • Kongeriget Danmark

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Taastrup 01 February 2002

Karin Schlichting
Head Clerk

CERTIFIED COPY OF
PRIORITY DOCUMENT

Patent- og
Varemærkestyrelsen
26 JAN. 2001
Modtaget

An electroacoustic transducer and a coil and a magnet circuit therefor

This invention relates to electroacoustic transducers, and in particular to electrodynamic transducers with a diaphragm carrying a coil of electrically conducting wire movable in a magnetic field.

Electroacoustic transducers, and in particular electrodynamic transducers, are widely used in telecommunications equipment such as wired and mobile telephones, where small size is a requirement. Traditional electrodynamic microphones and speaker transducers used in eg mobile telephones are rotational symmetric and have a circular disc or ring shaped permanent magnet, which is magnetised in the axial direction of the magnet. A magnet circuit of magnetically soft iron or other suitable material define a ring-shaped gap with a radially oriented magnetic field created by the magnet. A diaphragm carries a ring-shaped coil of electrically conducting wire situated in the gap.

If the inner and outer members defining the gap are not perfectly coaxial, the gap will not have a uniform width resulting in a distorted distribution of the magnetic field along the gap. A coil carrying electric currents at audio frequencies in such a distorted magnetic field will tend not to move in a linear movement but to tilt, which causes linear and non-linear distortion.

In such transducers the magnetic field in the ring-shaped gap is radially oriented, whereby the magnetic field is inherently stronger at its inner limit than at its outer

limit. A not perfectly centred coil will cause the same distortion as mentioned above.

Such inhomogeneities in the magnetic field are avoided with the invention, whereby a cleaner output from the transducer is obtained, whether the transducer is a microphone or a speaker transducer. The magnetic field is stronger than in the known transducers, whereby the transducers can be made even smaller and still have the same sensitivity, which will be appreciated by the manufacturers of eg mobile telephones. Further, due to the magnet circuit the transducer will have a reduced stray magnetic field relative to the traditional transducers.

In the following the invention will be explained in detail with reference to the drawings, in which

figure 1 is a perspective view showing a preferred embodiment of the invention with its essential parts exploded seen from above,

figure 2 shows the same parts in perspective seen from below,

figure 3 shows the magnet circuit of the transducer in figures 1-2, and

figure 4 shows a coil for use in the transducer of figures 1-2, at an intermediate production stage.

Figures 1 and 2 show an electrodynamic transducer 10 with its main components: a magnet circuit 20, a coil 30 and a diaphragm 40. Figure 3 also shows the magnet circuit 20.

As is best seen in figure 3, the magnet circuit 20 has two long legs 21 and two short legs 22 connected at their ends to form a ring of generally rectangular shape. A middle leg 23 interconnects the two short legs 22 dividing the internal of the rectangular ring into two rectangular openings 24. The two long legs 21, the two short legs 22 and the middle leg 23 of the magnet circuit are of a magnetically soft material preferably having a high magnetic saturation value. The faces of the two long legs 21 and of the middle leg 23 facing towards the openings 24 are generally plane and define a gap therebetween. On the plane side 25 of each of the long legs 21 facing the opening 24 is a magnet 26 attached to the sides 25. The magnets 26 each have a magnetic pole face attached to the long leg and the opposite free magnetic pole face 29 facing the opening and the opposed plane face 27 of the middle leg 23, whereby magnet gaps 28 are defined between the free magnetic pole faces 29 and the faces 27 of the middle leg.

Each magnet 26 creates a magnetic field in the corresponding gap 28, and the magnetic return paths are defined through the middle leg 23, the short legs 22 and the long legs 21. The magnetic return paths thus completely encircle the magnet gaps 28 with the magnets each having a magnetic pole face defining a gap 28. This gives a very flat and compact structure of the magnet system with the magnetic field concentrated in the gaps 28 and a low stray magnetic field, which results in a high sensitivity and less need for magnetic shielding. In figures 1 and 2 the magnet system 20 in figure 3 is situated in a plastic casing 50, eg by moulding or by fitting into a

preformed "box". The plastic casing may have a bottom closing the openings 24 or leave them open.

Figure 4 shows the coil 30 used in the transducer 10. The coil 30 is wound of electrically conducting thin wire such as copper and comprises a plurality of turns electrically insulated from each other, eg by means of a surface layer of lacquer. The coil has a coil axis perpendicular to the drawing. As is known in the art, the wire and the coil is heated during winding, whereby the lacquer becomes adhesive and adheres the windings to each other and thereby stabilises the coil mechanically. The wire of the coil 30 has two wire ends 31 for connecting the coil electrically to eg electronic circuits.

The coil 30 is wound on a mandrel of generally rectangular cross section, whereby the coil is given the shape shown in figure 4 with a generally rectangular opening 32 and a generally rectangular outer contour with rounded corners. In figure 4 the coil is relatively flat and has a thickness, which is less than its radial width between its inner and outer contours - typically 10-30 % of the radial width or according to the subsequent operations to be performed on the coil.

After the coil has been wound with the desired number of turns of wire and to the desired shape and thickness it is removed from the mandrel. While the coil is still warm, and the lacquer is still soft due to the elevated temperature, the coil is bent along two parallel bending axes 33 in the plane of the flat coil using a (not shown) bending instrument. The coil is hereby given the shape shown in figures 1 and 2, where the two long sections 34

of the coil have been bent 90 degrees relative to the two short sections 35, and the two long sections 34 are now parallel to each other. After the bending the coil is allowed to cool so that the lacquer is no longer flexible, and the coil stabilises.

The bent and stabilised coil is then secured to the diaphragm 40. The diaphragm is made from a thin and flexible sheet. On its lower side, which is the side shown in figure 2, the diaphragm 40 has electrically conductive portions 41, and the two short sections 35 of the coil are secured to the lower side of the diaphragm, eg by means of an adhesive, with the two wire ends 31 electrically connected to respective ones of the electrically conductive portions 41, eg by soldering or welding. The diaphragm 40 is rectangular in shape, and tongues 42 extend from the long sides of the diaphragm with the electrically conductive portions 41 extending to the tongues, so that the electrically conductive portions 41 on the tongues are electrically connected to respective ones of the coil wire ends 31.

The diaphragm 40 with the coil 30 thus secured thereto is then mounted on the magnet system 20 with the two long sections 34 of the coil in respective ones of the gaps 28. The long sections 34 are therefore also referred to as gap portions of the coil. The two short sections 35 of the coil will be situated over the middle leg 23 and will bridge the two gap portions of the coil. The diaphragm will be secured to the magnet system along its long edges. The diaphragm has a width corresponding to the distance between the inner sides of the edges 51 of the casing. If desired, the long edges of the diaphragm may

be secured to the magnet system by means of an adhesive. The short sides of the diaphragm are preferably free, whereby a narrow slot is provided giving access of air between the two sides of the diaphragm. The slot can be tuned to have desired acoustic properties influencing the acoustic performance of the transducer, in particular at low frequencies. If desired, the short edges of the diaphragm can also be secured to the magnet system, or the slot can be closed with a substance allowing the edges to move. In the preferred embodiment the diaphragm is rectangular, but other shapes can be used.

In figure 1 it is seen that the magnet circuit is laminated from several layers, and that the uppermost layer the middle leg 23 the is omitted, so that the uppermost layer has the shape of the generally rectangular ring with two long legs and two short legs. The "missing" part of the middle leg gives room for accommodating the bridging portions 35 of the coil. The magnet circuit may also be made as one solid block or as an outer ring with the middle leg inserted therein.

Figures 1 and 2 also show that, on its sides, the plastic casing 50 has two grooves or channels 52 ending on the bottom of the casing 50. The channels 52 have a width corresponding the width of the tongues 42. The tongues 42 will be bent and received in respective ones of the channels 52 with the ends of the tongues received in the part of the grooves at the bottom of the casing 50. The ends of the tongues will be bent 180 degrees so that the end of the conductive portion becomes exposed, or a through-plated hole will establish electrical connection through the tongue. The end portions of the conductive portions

of the tongues will thus act as the electrical terminals of the transducer.

The transducer will preferably have a front cover with openings in front of the diaphragm. The transducer may be used as a microphone or as a speaker transducer in telecommunications equipment such as mobile telephones.

The rectangular diaphragm is retained along two opposed edges, preferably the long edges and free at the two other edges. Hereby a simple bending motion of the diaphragm is obtained, and in comparison to transducers having their diaphragm retained along the entire periphery the transducer of the invention will have a relatively high sensitivity even with a relatively thick diaphragm.

The transducer is equally suitable as a speaker transducer and as a microphone. When used as a speaker transducer, electrical signals at audio frequencies are supplied to the terminals, and the resulting current in the gap portions of the coil wire will interact with the magnetic field in the gaps and cause the coil and the diaphragm to move and generate sound at the audio frequencies. Likewise when used as a microphone, sound at audio frequencies acting on the diaphragm will cause it to move, and when the gap portions of the coil wire move in the magnetic field electrical signals will be generated and output on the terminals of the transducer.

In the preferred embodiment the magnet circuit is rectangular, and there are two gaps receiving the gap portions of the coils, where the gaps are defined between opposed plane faces. In another configuration the magnet circuit could have four gaps arranged like the sides of a square,

and the coil would then correspondingly have four gap portions likewise arranged like the sides of a square. The bridging portions of the coil would then be at the corners of the square and be secured to the diaphragm at four locations. The outer contour of the magnet circuit can have any desired shape including circular shape. Also, the gaps and the gap portions of the coils can be curved as arcs of a circle.

Claims

1. An electroacoustic transducer (10) comprising

- a magnet circuit (20) of a magnetically conductive material with a pair of opposed faces (27, 29) defining a gap (28) therebetween, and a magnet (26) causing a magnetic field to exist in the gap (28),

- a diaphragm (40),

- a coil (30) of electrically conducting wire secured to the diaphragm (40), the coil (30) having portions (34) of its wire situated in the gap (28),

c h a r a c t e r i z e d in that the magnet circuit (20) has two pairs of opposed faces (27, 29) defining first and second gaps (28), and that the coil (30) has first and second gap portions (34) of its wire situated in respective ones of the first and second gaps (28), and bridging portions (35) of the wire interconnecting the first and second gap portions (34) of wire, with the coil (30) secured to the diaphragm (40) at the bridging portions (35) of wire.

2. A transducer according to claim 1, c h a r a c t e r i z e d in that each pair of opposed faces (27, 29) are substantially plane faces parallel to each other.

3. A transducer (10) according to claim 2, c h a r a c t e r i z e d in that each magnet (26) has opposed plane faces and is attached to one of the substantially plane faces (27, 29) of a gap (28).

4. A transducer (10) according to any one of claims 1-3, characterized in that the magnet circuit (20) includes a body of magnetically soft material (21, 22, 23) with two openings (24) therein, each opening (24) having a pair of opposed faces (27, 29) defining respective ones of the first and second gaps (28).

5. A transducer (10) according to claim 4, characterized in that the openings (24) in the magnet circuit are through-going, and that the magnetically conductive material (21, 22,23) defines respective magnetic return paths between each pair of opposed of faces (27, 29) defining a gap (28).

6. A transducer (10) according to any one of claims 1-5, characterized in that the diaphragm (40) has electrically conductive portions (41), and the coil (30) has wire ends (31) connected electrically to the electrically conductive portions (41) of the diaphragm (40), and the electrically conductive portions (41) have externally accessible portions for electrically terminating the transducer.

7. A coil (30) of electrically conducting wire for use in a transducer (10) according to any one of claims 1-6, characterized in that the coil (30) has bridging portions (35) defining a bridging plane with a substantially flat face for securing to a diaphragm (40), and gap portions (34) outside the bridging plane, each gap portion (34) including a plurality of segments of wire outside the bridging plane and substantially parallel to the bridging plane.

8. A coil (30) according to claim 7, c h a r a c t e r i z e d in that the segments of wire in the gap portions (34) are substantially linear.

9. A method of manufacturing a coil (30) from an electrically conducting wire, the method comprising

- producing, from an electrically conducting wire, a coil defining a coil axis,

- bending the coil (30) around two bending axes (33) perpendicular to the coil axis.

10. A magnet circuit (20) for use in an electroacoustic transducer (10) according to any one of claims 1-6 and having a magnetically conductive material with a pair of opposed faces (27, 29) defining a gap (28) therebetween for receiving portions of a coil of electrically conducting wire, and a magnet (26) causing a magnetic field to exist in the gap (28), c h a r a c t e r i z e d in that the magnet circuit (20) has two pairs of opposed faces (27, 29) defining first and second gaps (28).

11. A magnet circuit (20) according to claim 10, c h a r a c t e r i z e d in that each pair of opposed faces (27, 29) are substantially plane faces parallel to each other.

12. A magnet circuit (20) according to claim 11, c h a r a c t e r i z e d in that each magnet (26) has opposed plane faces and is attached to one of the substantially plane faces (27, 29) of a gap (28).

13. A magnet circuit (20) according to any one of claims 10-12, c h a r a c t e r i z e d in that the magnet cir-

cuit (20) includes a body of magnetically soft material (21, 22, 23) with two openings (24) therein, each opening (24) having a pair of opposed faces (27, 29) defining respective ones of the first and second gaps (28).

14. A magnet circuit (20) according to claim 13, c h a - r a c t e r i z e d in that the openings (24) in the magnet circuit are through-going, and that the magnetically conductive material (21, 22,23) defines respective magnetic return paths between each pair of opposed of faces (27, 29) defining a gap (28).

Abstract

An electroacoustic transducer (10) has a magnet circuit (20) of a magnetically conductive material with a pair of opposed faces (27, 29) defining a gap (28), and a magnet (26) causing a magnetic field to exist in the gap (28). A diaphragm (40) has a coil (30) of electrically conducting wire secured to the diaphragm (40), and the coil (30) has portions (34) of its wire situated in the gap (28). The magnet circuit (20) has two pairs of opposed faces (27, 29) defining first and second gaps (28), and that the coil (30) has first and second gap portions (34) of its wire situated in respective ones of the first and second gaps (28). Bridging portions (35) of the wire interconnect the first and second gap portions (34) of wire with the coil (30) secured to the diaphragm (40) at the bridging portions (35) of wire. The transducer can be made very compact and with a very high sensitivity.

Figure 1 should be published

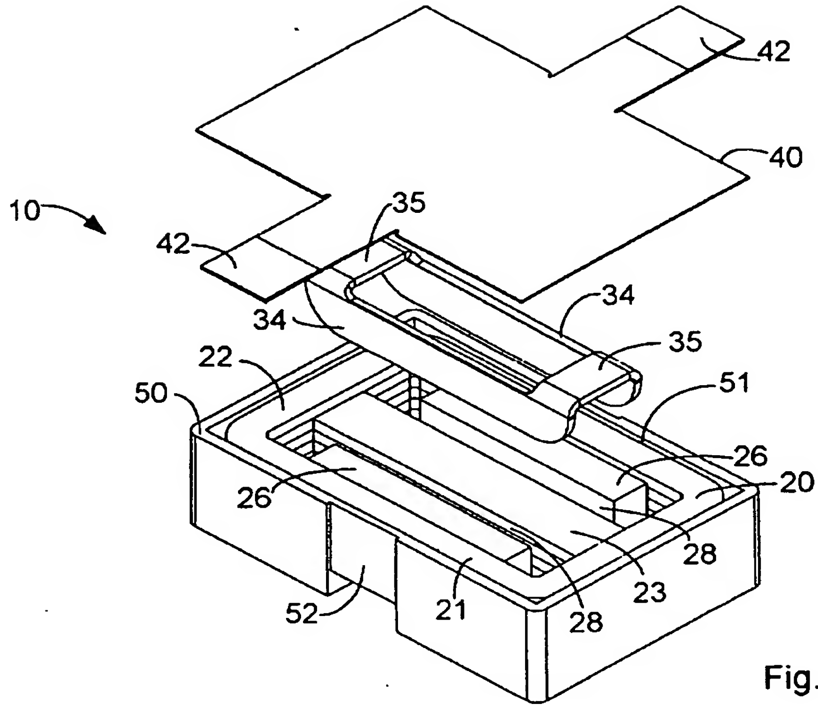
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Fig. 1

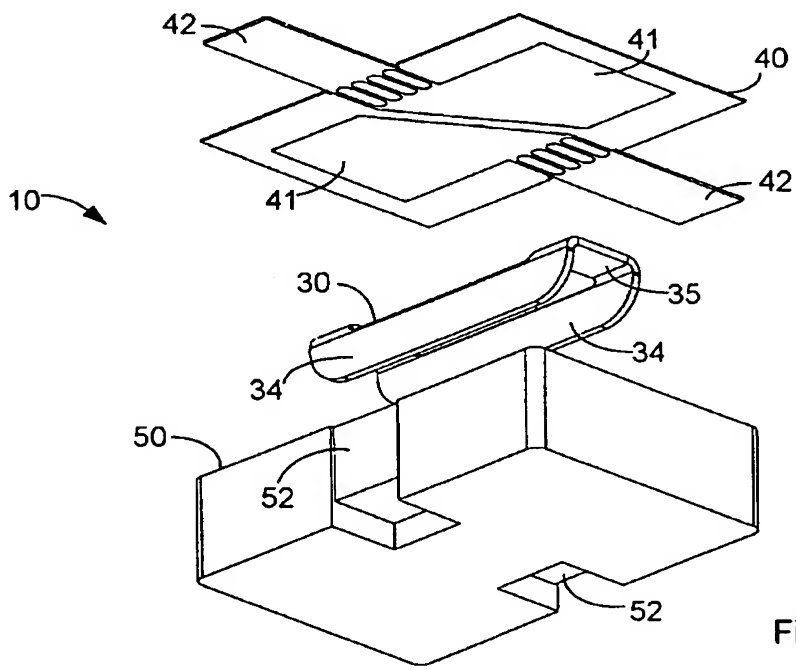
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Fig. 2

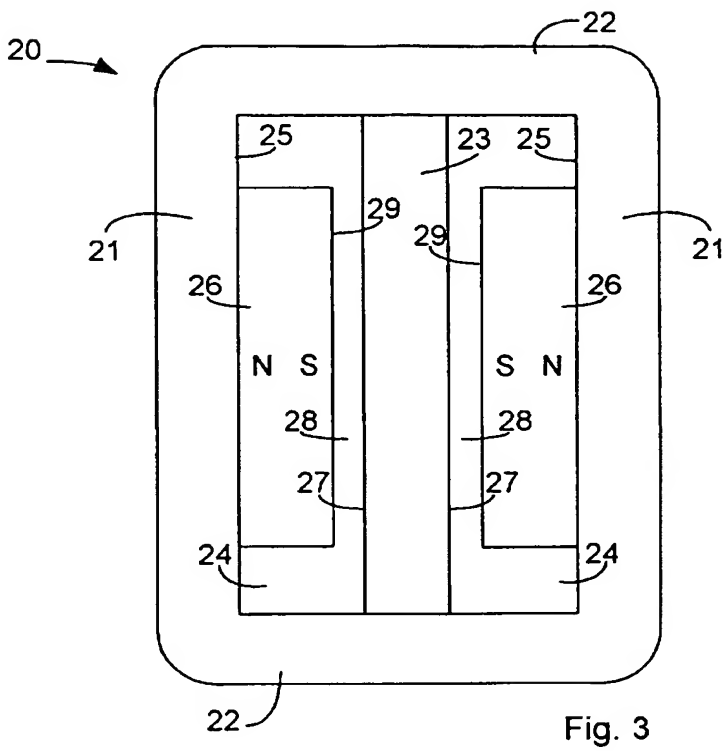
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Fig. 3

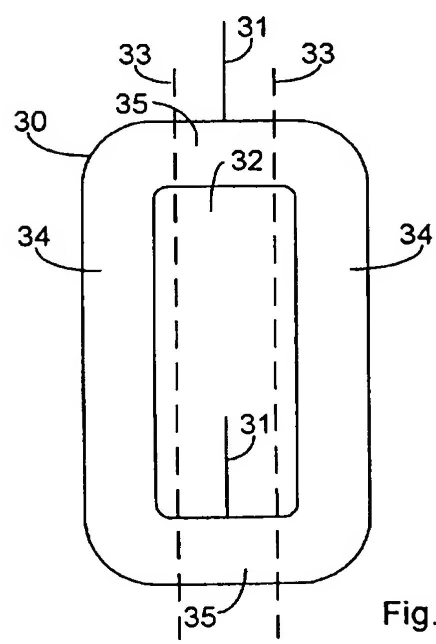
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Fig. 4